



INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Benefits Of Using *Azolla* In Cattle Farming

Saket Verma, Ajay Kumar Harit & Urvashi Sharma

Department of Zoology, Kalinga University, Raipur

Abstract:

India possesses the most substantial livestock population globally. To satisfy both current and anticipated demands of the expanding human demographic, it is imperative to adopt innovative strategies to fulfill the input requirements to produce livestock and their derived products. Although India ranks first in the world regarding milk production and bovine population, the average productivity still necessitates enhancement; this may be attributable to a suboptimal nutritional status resulting from inadequate availability of high-quality fodder and feed. Consequently, there has been a concerted effort to identify alternative sources of superior-quality unconventional feed and fodder to facilitate efficient livestock production. In the quest for substitutes to traditional concentrates and fodder/feed for various animal species, a remarkable plant known as azolla has emerged, which holds significant promise as a sustainable feed source for livestock. Given that azolla encompasses the majority of nutrients requisite for all categories of livestock, including poultry and fish, it can be administered to these animals without any detrimental effects. Numerous studies have indicated that the incorporation of azolla in the diets of dairy cows can enhance milk production by 15 to 20 percent.

Keywords: Azolla, livestock, cow feed, azolla production, sustainable

1.Introduction

Notwithstanding its status as the largest producer of milk globally, India grapples with a significant deficiency in feed and fodder for its dairy livestock. The shortages of dry fodder, green fodder, and concentrate have been approximated at 12 to 14 percent, 25 to 30 percent, and 30 to 35 percent, respectively. Consequently, this inadequacy of fodder necessitates the utilization of commercially prepared feed, which in turn escalates the expenses associated with milk production. The exploration of alternatives to green fodder and concentrates has led to the identification of a remarkable plant, Azolla, which presents a viable prospect for sustainable livestock feed.

Azolla is characterized as a free-floating, rapidly proliferating aquatic fern that resides on the surface of water bodies. It appears as a diminutive, flat, and compact green mass. Under optimal conditions, its growth is exponential, with biomass doubling approximately every three days. There exist at least eight species of Azolla on a global scale, namely: *Azolla caroliniana*, *Azolla circinata*, *Azolla japonica*, *Azolla mexicana*, *Azolla microphylla*, *Azolla nilotica*, *Azolla pinnata*, and *Azolla rubra*. The predominant species of Azolla found in

India is *Azolla pinnata*. This species produces a protein yield exceeding 4 to 5 times that of lucerne and hybrid napier in terms of superior quality. Moreover, its biomass production is nearly 4 to 10 times greater when juxtaposed with hybrid napier and lucerne, respectively. These two parameters are critically significant in enhancing the economic viability of livestock production, thereby establishing *Azolla*'s reputation as “The Super Plant.”

The escalating demand for dairy products in India is engendering novel opportunities for enhancing the profitability of animal husbandry as a professional pursuit. Concurrently, however, there exists a significant reduction in the availability of fodder resources. The expanse dedicated to forests and grasslands is diminishing, alongside a decline in the quantity of various crop residues accessible for animal feed, predominantly attributable to the proliferation of high-yielding dwarf crop varieties. Consequently, the deficiency of fodder is being mitigated through the utilization of commercial feed, which in turn results in elevated production costs for meat and milk. Furthermore, the incorporation of urea and other synthetic milk enhancers into commercial feed adversely impacts both the quality of milk produced and the overall health of the livestock.

Azolla serves as a host to the symbiotic cyanobacterium, *Anabaena azollae*, which plays a crucial role in the fixation and assimilation of atmospheric nitrogen. In reciprocity, *Azolla* provides the necessary carbon substrates and conducive environmental conditions for the proliferation and development of the algae. This distinctive symbiotic interaction is what renders *Azolla* an exceptional plant characterized by its high protein content {(Kamalasanana Pillai et al, 2002)}. The dairy industry emerged as a predominant occupation in rural areas due to the decline of agriculture. With the escalating demand for milk, animal husbandry has evolved into a lucrative source of income for the rural impoverished. The cultivation of dwarf crops coupled with the reduction of forest and grazing lands has led to a sustainable reduction in fodder production. *Azolla* is classified as a floating fern that thrives in shallow aquatic environments.

Azolla is exceptionally abundant in proteins, essential amino acids, vitamins (A, B12, beta-carotene), growth-promoting intermediaries, and minerals (such as calcium, phosphorus, potassium, iron, copper, and magnesium) {(Pascal Letermea et al, 2010)}. *Azolla*, when evaluated on a dry weight basis, comprises 25.35 percent protein, 10.15 percent amino acids, bioactive compounds, and biopolymers. The concentrations of carbohydrates and lipids within *Azolla* are notably minimal. The digestibility of *Azolla* by livestock is facilitated by its high protein content and low lignin levels. The incorporation of *Azolla* into livestock diets has been associated with a 15 to 20 percent increase in milk yield. Furthermore, *Azolla* can replace 15 to 20 percent of commercial feed without adversely impacting milk production, while simultaneously enhancing milk quality and promoting the health and longevity of livestock.

Dairy producers predominantly rely on commercial feeds, which are often supplemented with urea and synthetic milk enhancers. Such practices may adversely influence the quality of milk produced as well as the lifespan of the animals. This situation may, in turn, contribute to the development of cancer and cardiovascular diseases in humans. The utilization of commercial feed is not financially viable and can lead to reduced income. In contrast, *Azolla* represents a highly economical and effective alternative feed source for livestock. Livestock is instrumental in sustaining the livelihoods of individuals by providing food, financial resources, draft power, manure, and fulfilling various social and cultural roles {(CSA, 2015; Shiferaw et al., 2011)}. Additionally, in certain nations, livestock, particularly cattle, serve as indicators of an individual's wealth and social standing

{(Herrero et al., 2013)}. On a global scale, livestock-derived products account for 17% of total kilocalorie intake and 33% of protein consumption {(Rosegrant et al., 2009)}. The demand for livestock products is escalating, particularly in developing nations {(Thornton, 2010)}. In numerous developing countries such as Ethiopia, Tanzania, and Kenya, livestock-derived products are a crucial source of nutrients essential for enhancing the nutritional well-being of the populace {(Engida et al., 2015; Molina-Flores et al., 2020)}.

Azolla has progressively disseminated across various global regions, including Africa, Asia, Europe, North America, Oceania, and South America, either through accidental introduction or as an ornamental species. Its initial discovery was recorded in Europe, North and sub-Saharan Africa, China, Japan, New Zealand, Australia, the Caribbean, and Hawaii.

Azolla encompasses nearly all essential and high-quality protein sources, being rich in crude protein, essential amino acids, vitamins, growth-promoting intermediates, and minerals including calcium, phosphorus, potassium, iron, copper, and magnesium. On a dry weight basis, it typically contains 25–35% protein, 10–15% minerals, 7–10% amino acids, bioactive compounds, and biopolymers, along with 15% total ash. The low lignin content facilitates its digestibility in animals; they can rapidly adapt to its inclusion in their diet; it is cost-effective to cultivate; and it contains ether extracts that are vital for ruminant nutrition.

2. Methodology

2.1 Azolla production

A water body is constructed, ideally positioned beneath the canopy of a tree, utilizing a silpauline sheet as the primary material. Silpauline refers to a polyethylene tarpaulin that exhibits resistance to ultraviolet radiation emitted by sunlight. The initial procedure involves excavating a pit measuring 2 m x 2 m x 0.2 m in dimensions. Subsequently, the pit is lined with plastic gunnies to inhibit the penetration of nearby tree roots into the silpauline sheet. The silpauline sheet is then deployed over the plastic gunnies. An approximate quantity of 10 – 15 kgs of sieved fertile soil is evenly distributed across the silpauline sheet. A slurry composed of 2 kg of cow dung and 30 grams of super phosphate dissolved in 10 litres of water is introduced into the sheet. Additional water is then added to elevate the water level to approximately 10 cm. Between 500 grams and 1 kg of fresh and uncontaminated Azolla culture is inoculated into the pit. The Azolla is expected to proliferate rapidly, occupying the entirety of the pit within a span of 10 – 15 days. Thereafter, a daily harvest of approximately 500 – 600 grams of Azolla can be achieved. To facilitate the continuous rapid multiplication of Azolla, a mixture containing 20 grams of super phosphate and approximately 1 kg of cow dung should be administered every five days. A micronutrient mixture comprising trace elements is to be added at weekly intervals to augment the mineral content of Azolla. Utilizing this methodology, the production cost of Azolla is less than 65 paise per pit. A farmer may attain a harvest of up to 750 tonnes of Azolla from a single acre. It is imperative that the bed remains moist and shaded.

2.2 Environmental conditions for azolla production

Azolla production is predominantly contingent upon the chemical and biological characteristics of water; thus, irrespective of water quality, the uninterrupted availability of water throughout the year is critically essential to produce the requisite quantity of Azolla for consistent utilization. Azolla possesses the capacity for rapid growth, with its biomass capable of doubling in a span of 2–5 days, leading to the formation of exceedingly dense mats in conducive environments, which presents numerous challenges for aquatic transportation, fauna, and indigenous plant species, as well as contributing to the phenomenon of eutrophication. The availability of water is paramount for its growth. Optimal light intensity (15–18 lux), temperature (18°–28°C), and relative humidity (55–83%) collectively facilitate enhanced growth. Azolla can experience fragmentation and mortality due to wind and turbulent aquatic conditions.

In general, the optimal temperature for Azolla growth is found to range from 20 to 30°C. Temperatures exceeding 37°C adversely affect the multiplication of Azolla. The ideal relative humidity is established to be between 85 and 90%. The preferred pH range for optimal growth is identified as being from 5.5 to 7. This fern exhibits detrimental effects when exposed to excessively acidic or alkaline pH levels. Suboptimal growth conditions characterized by low light intensity; 90% humidity, absence of nitrogen, and lack of pH regulation resulted in a significantly reduced growth rate of 0.064 days. Conversely, high biomass yields can be achieved by employing the optimal growth conditions identified in the research. This biomass has potential applications in phytoremediation, among other uses. Azolla is classified as a macrophyte that flourishes proficiently within Malaysia's climatic conditions. The ideal growth parameters were determined to include a water depth of 20 cm, a nutrient concentration of 812.5 ppm, a pH level of 7.0, an average daily temperature in Malaysia ranging from 21°C to 32°C, and complete sunlight exposure. The maximum growth rate of *Azolla filiculoides* is attained within 2.1 days at a temperature of 22°C, with a light intensity of 20 lx, humidity of 75%, and a pH of 6.4. Additionally, a predictive model has been proposed that accounts for the influence of critical variables on the growth rate of Azolla.

The optimal environmental conditions to produce Azolla (*Azolla pinnata*) include a temperature range of 28.94–33.46°C, a light intensity range of 1413.29–1561.57 Lux, and a relative humidity percentage between 47.28–64.85%. These conditions yielded a weekly vegetative mass output of 3.73 kg and a dry matter yield of 172 g per pit. When assessed against pig manure, the manures of cattle, sheep, and poultry demonstrated comparable and superior efficacy. Among the various factors influencing the growth rate of Azolla, pH emerges as the most significant. The most rapid growth is observed at a pH of 7. Azolla exhibits markedly diminished growth at pH levels that deviate from 7 in either direction; however, a slightly acidic environment is more conducive to Azolla development than a neutral one. Given that N₂ fixation was impeded, the optimization of other parameters had a beneficial impact on the growth and propagation of Azolla in acidic pH conditions.

2.3 Economics of azolla production

The production of Azolla in a single unit over the course of one year is approximately 680 kg.

Materials	Cost
Digging charges of trench (size of unit 6.0 x 1.0 x 0.2 mt)	Rs. 100.00
Cost of silpauline sheet (120 G)	Rs. 350.00
Nylon Shady net 50 % (7 x 2 mt). Rs. 420.00 Nylon Shady net 50 % (7 x 2 mt). Rs. 420.00 @ Rs. 30/- mt	Rs. 420.00
Azolla 2 kg @ Rs. 50/-kg	Rs. 100.00
Cow dung 70 kg (5-10 kg. + 5kg. /month)	Rs. 70 .00
Super phosphate 240 gms. @20 gm. / month	Rs. 2.00
Total	Rs. 1042.00

2.4 Azolla as cow feed

Freshly harvested Azolla can be incorporated with commercial livestock feed in a ratio of 1:1 or administered directly to the animals. Research has demonstrated that milk production in cattle can experience an increase of 10-12 percent when supplemented with Azolla, alongside a 20-25 percent reduction in expenditures associated with commercial feed purchases. The composition of milk is a critical determinant of its market value, and consequently, total farm revenue. Evidence indicates a 10% enhancement in milk yield, along with a 0.5% increase in fat and solid-non-fat (SNF) content in milk when Azolla is included in the diet {(Baghel, 2007)}. This practice results in a cost saving of Rs. 6 per animal per day due to a 25% substitution of concentrates with Azolla, coupled with an additional revenue of Rs. 9 per animal per day attributable to improvements in both the quantity and quality of milk produced.

The incorporation of Azolla pinnata as a viable alternative feed source for crossbred dairy cattle has demonstrated that substituting commercial feed with quantities ranging from 15% to 25% of Azolla pinnata can enhance both the fat percentage and the overall milk yield by approximately 7% to 13%. Furthermore, the economically advantageous supplementation of Azolla has the potential to augment the average economic returns derived from a single dairy cow in rural settings by elevating the monthly milk production. The growth performance and nutrient digestibility associated with the feeding of Azolla pinnata in Sahiwal Calves {(Bos indicus)}, when replacing concentrate protein content at levels of 15% and 30%, could significantly enhance the growth metrics of Sahiwal female calves throughout the winter months. The crude protein content in Azolla pinnata at concentrations of 15% and 30% has the potential to substantially enhance the growth performance of Sahiwal female calves

2.5 Current Status and Future Perspective of Azolla Production

It is imperative to screen Azolla strains from diverse agroecological zones that exhibit efficacy in nitrogen fixation, and to evaluate their performance under a variety of abiotic stressors, including salinity, heavy metal exposure, and ultraviolet-B radiation. There is a pressing need to leverage advancements in molecular biology to enhance these strains. Research initiatives should concentrate on the development of Azolla cultures that exhibit increased resilience to environmental fluctuations, such as alterations in soil pH, temperature variations, salinity, and contamination by heavy metals. To effectively address the abiotic stress tolerance of Azolla species across varying agroclimatic zones for atmospheric nitrogen harvesting and the bioremediation of heavy metals, the application of genetic engineering techniques may prove to be advantageous.

The utilization of the aquatic fern Azolla necessitates minimal effort and is associated with a reduced risk profile. Given that temperature constitutes a critical climatic determinant in plant growth, temperature-tolerant species emerge as a significant focus of inquiry within the framework of a shifting climate. Further investigation into the phytoremediation capabilities of decomposed Azolla biomass is warranted; however, its practicality is underscored by the ease of its cultivation during appropriate seasons, the straightforward storage of dry biomass, the uncomplicated transportation of biomass for sustainable applications, and the manageable disposal of contaminated biomass following conversion to ash and deep burial in wastelands. The methodologies employing Azolla biotechnology are advancing swiftly and are expected to continue evolving in the future. A primary enhancement of Azolla efficiency has been a pivotal consideration in the evolution of molecular genetics, cellular and genetic engineering, as well as genome editing. To augment the concentrations of secondary metabolites and nutrients within aquatic plants, foundational genetic and genetic engineering research must also be integrated.

3.Result

The empirical data indicated that there was a 20.96 percent augmentation in the milk yield of bovines when their diet was augmented with Azolla, concurrently leading to a 16.90 percent enhancement in the milk yield of buffaloes. The milk yield and fat percentage exhibited an increase from 1.0 to 1.5 litres and from 4.3 to 4.7 percent in cows, and from 1.0 to 1.4 litres and from 6.2 to 6.9 percent in buffaloes, respectively. Furthermore, it was observed that the incorporation of Azolla with conventional feed resulted in an increase in milk yield, with the potential for 15-20 percent of commercial feed {(Kamalasanana et al (2002))} to be substituted with an equivalent quantity of Azolla on a dry weight basis, without compromising milk production, thereby providing a financial advantage of 20 to 25 percent in the procurement of commercial feeds. The consensus among farmers was that their livestock began to exhibit remarkable signs of health, including an improved coat condition, brightness of the eyes, moistness of the muzzle, and heightened activity following the administration of Azolla.

Parameter	Initial	Final
Milk yield (l/d)	7.10	8.30
Milk fat (%)	6.2	6..9

4. Conclusion

Azolla is posited as an optimal feed source for cattle, aquatic animals, swine, and poultry, and additionally holds significant potential as a biofertilizer for paddy cultivation in wetland environments. It has gained popularity and is extensively cultivated in countries such as China, Vietnam, and the Philippines; however, its adoption in India remains limited. Dairy producers in regions of South Kerala, Kanyakumari, and northern Karnataka have commenced the implementation of cost-effective production methodologies, and it is anticipated that the utilization of Azolla technology will expand among dairy farmers, particularly those with insufficient land for fodder cultivation. Based on the findings of this study, it can be inferred that Azolla, as an unconventional feed resource, possesses significant potential for incorporation into the diets of non-ruminant livestock. Notably, for optimal performance, the diets of pullet chicks may be formulated with the integration of Azolla up to 10 percent. Both Azolla and *Salvinia* serve as commendable sources of minerals and essential amino acids; however, their application in swine production is somewhat constrained due to their relatively low digestible energy and protein content.

Given that Azolla comprises a higher proportion of cell wall fractions, it is advisable to supplement the diets of livestock with cellulolytic enzyme preparations to enhance the performance and productivity of the animals. Up to 15 to 20 percent of Azolla may be incorporated into the dietary regimen of dairy cows as a substitute for concentrated feed. Nonetheless, further investigations are warranted to evaluate the efficacy of Azolla utilization.

References: -

- [1] Kamalasanana P, Premalatha, S and Rajamony, S (2002). Azolla – A sustainable feed substitute for livestock. *Leisa India*, March, 2002, pp. 15-17.
- [2] Shiferaw, A., Puskur, R., Tegegne, A., & Hoekstra, D. (2011). Innovation in forage development: Empirical evidence from Alaba Special District, Southern Ethiopia. *Development in Practice*, 21(8), 1138–1152. <https://doi.org/10.1080/09614524.2011.591186>
- [3] Herrero, M., Grace, D., Njuki, J., Johnson, N., Enahoro, D., Silvestri, S., & Rufino, M. C. (2013). The roles of livestock in developing countries. *Animal: An International Journal of Animal Bioscience*, 7 Suppl 1(1), 3–18. <https://doi.org/10.1017/S1751731112001954>
- [4] Rosegrant, M. W., Fernández, M., Sinha, A., Alder, J., Ahammad, H., Fraiture, C. D., & Yana-Shapiro, H. (2009). Agriculture at a crossroads. International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD), Global Report. <https://cgspace.cgiar.org/server/api/core/bitstreams/ddd3db25-2c8a-47ea-87fe-e1c73881bae/content>
- [5] Thornton, P. K. (2010). Livestock production: Recent trends, future prospects. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 365(1554), 2853–2867. <https://doi.org/10.1098/rstb.2010.0134>
- [6] Engida, E., Guthiga, P., & Karugia, J. (2015). The role of livestock in the Tanzanian economy: Policy analysis using a dynamic computable general equilibrium model for Tanzania (No. 1008-2016-80109). International Conference of Agricultural Economics, Milan, Italy. <https://doi.org/10.22004/ag.econ.212039>

- [7] Molina-Flores, B., Manzano-Baena, P., & Coulibaly, M. D. (2020). The role of livestock in food security, poverty reduction and wealth creation in West Africa. Food and Agriculture Organization of the United Nations (FAO). <https://doi.org/10.4060/ca8385en>
- [8] Kamalasanana Pillai. P., Premalatha. S. and Rajamony S., (2002). “AZOLLA – A sustainable feed substitute for livestock” LEISA India, 4: (1). It is available on the website www.leisa.info. Natural Resources Development Project, Vivekananda Kendra, Kanyakumari 629 702, India. Email: vknardep@md5.vsnl.net.in
- [9] Pascal Leterme, Angela M. Londoño, Diana C. Ordoñez, Alejandra Rosales, Fernando Estrada, Jérôme Bindelle, André Buldgen, (2010). Nutritional value and intake of aquatic ferns (*Azolla filiculoides* Lam. and *Salvinia molesta* Mitchell.) in sows, Anim. Feed. Sci. and Techn. 155: (1). 55-64
- [10] Baghel, R.P.S., (2007). Milk production and its composition effected by diet and its nutritional management. National Symposium on Recent trends in policy initiatives and technological interventions for rural prosperity in small holder livestock production systems. June, 20-22 pp. 135-143

